Water Reuse Systems

Water reuse systems may be an effective technique for improving irrigation system efficiencies and water management within a district. In addition to reducing the required diversion amount and increasing delivery flexibility, reuse systems may provide benefits in the areas of flood protection, erosion control, and water quality of receiving waters. It may also be possible to locate and schedule crop irrigation to effectively take advantage of water reuse opportunities.

The purpose of reuse systems is to capture system spills, seepage, and drainage waters for immediate or later use. In the case of operational spills, a storage facility is usually required to hold water until demand increases once again. In contrast, it may be possible to use captured drainage water on a more immediate basis, and a storage reservoir may not be required. Reuse of water potentially reduces the required amount of diversion into the overall system.

As shown in Figure 10, a reuse system will include a capture mechanism (a drainage canal or a diversion facility and reservoir) and the necessary pumping equipment and pipeline to deliver water from the capture location back into the application system. In some instances, it may be possible to use gravity for the delivery of the collected spills or drainage water.
In a system aimed at reuse of operational spills, it may be most efficient to capture spills at several locations in the conveyance

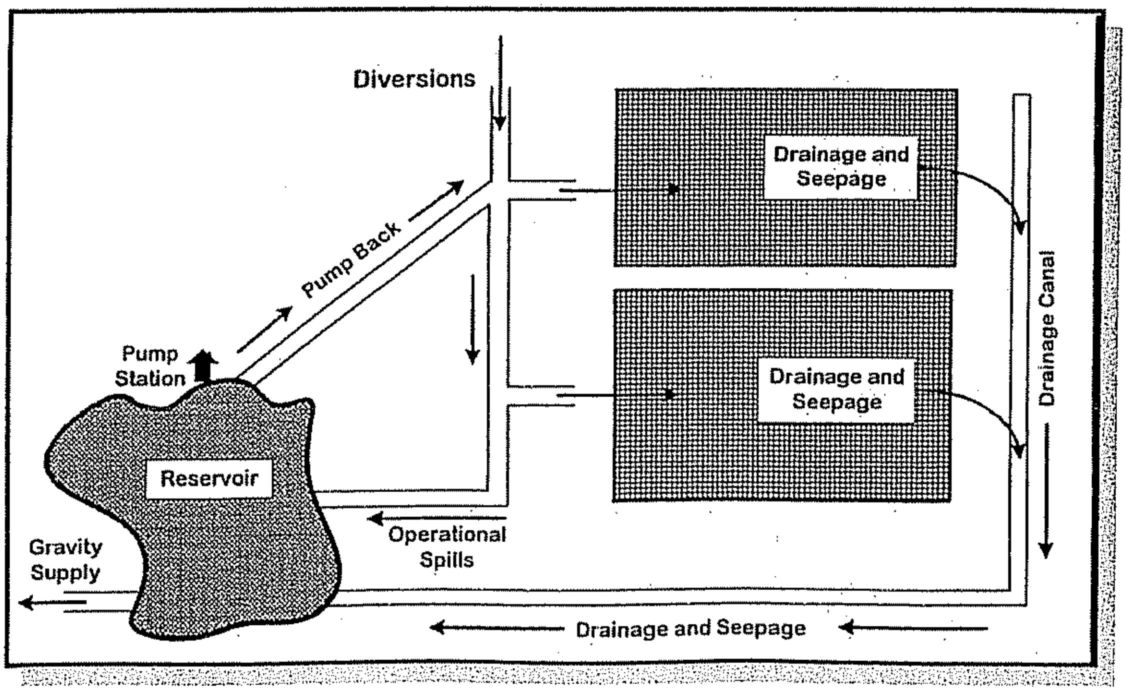


Figure 10: Irrigation Water Reuse Systems to Capture Spills and Drainage

system. Alternatively, the captured spills could be conveyed to a central storage location. The storage capacity required would typically depend on the flow rate in the service canal and the response time to changes in water demand.

Capture and reuse of operational spills as a conservation measure may be closely related to use of regulatory storage in the conveyance system. The use of regulatory reservoirs at higher points in the system may greatly improve the district's ability to respond to changing water demands and thus, substantially reduce operational spills. It may also be more efficient to implement both measures and use the regulatory reservoirs for storage of pumped spill water.

In addition to capturing spilled water, capture and reuse of drainage water may be advantageous at more than one location in the system. Several drainage canals can be constructed at key locations in the service area to capture seepage from specific areas that exhibit the most significant drainage problems. This collected water is then conveyed to a central location. It may be possible to use common storage reservoirs for both captured spills and drainage waters.

To evaluate the relevance of these management measures, you should consider the following questions for your district:

? **Does your district regularly experience operational spills?**

? **Are spills frequent and do they involve significant amounts of water?**

? **Do system spills or irrigation drainage cause problems downstream from erosion, flooding, water logging, or water quality?**

? **Would a reuse system provide additional flexibility to your district in the amounts and timing of water deliveries?**

? **Could the district reduce its overall diversion through implementation of a reuse program?**

Installation of Remote or Automated Controls

Advances in electronic sensing and automatic control equipment can improve the way water is managed and controlled. Automation can provide water managers instant information about flows and gate openings and give them the ability to change gate settings and flows without visiting the site. Benefits of automation can include more precise control of flows, more reliable service to irrigators, less waste through unnecessary spills, and reduced labor.

The following questions will help the district evaluate relevance of this measure:

? **Could the district reduce long travel times required for operators to take flow measurements or adjust control gate settings?**

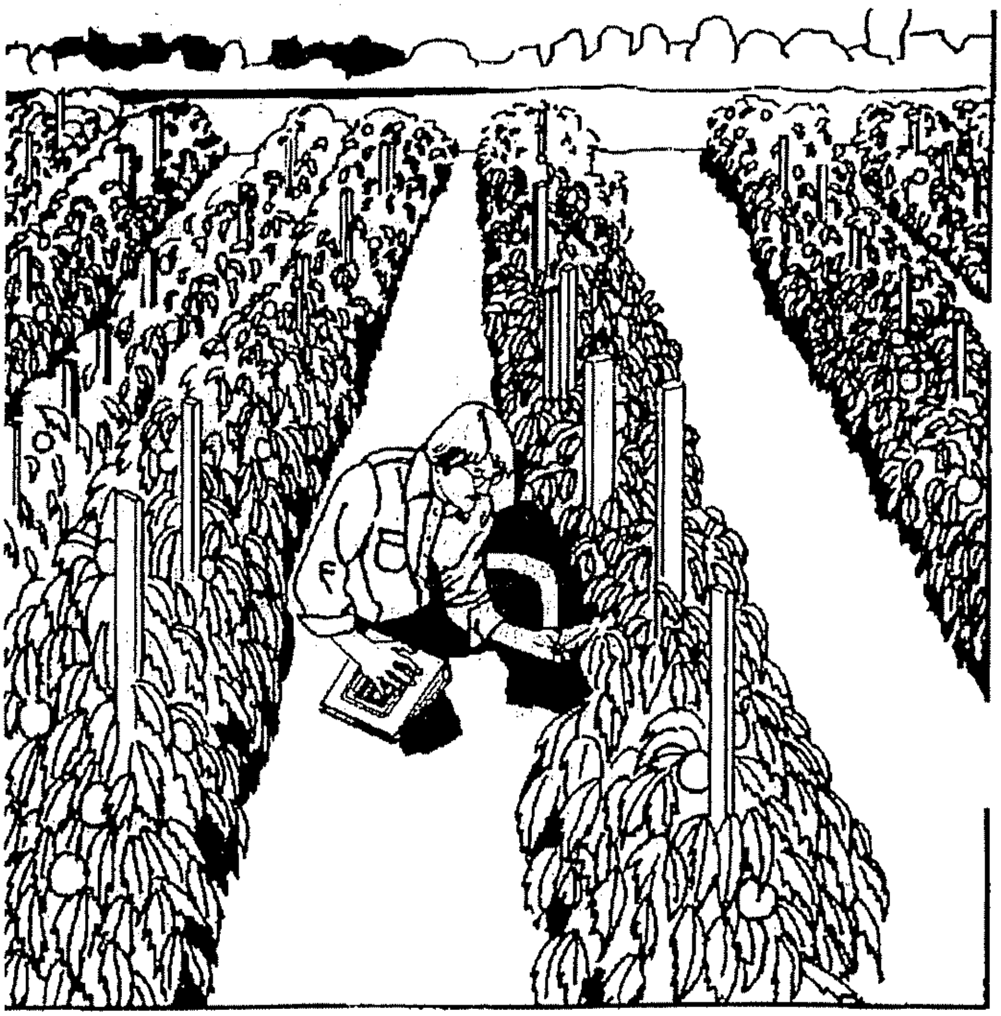
? **Do irrigators frequently complain about the reliability of service–deliveries are not on time or in the amount requested?**

? **Are significant quantities of water wasted because the district cannot quickly adjust diversions to respond to changing demands?**

SECTION FOUR – ASSEMBLING A WATER MANAGEMENT PLAN

This section of the Guidebook will help you prepare a document describing your water management action plan. It will:

- Describe the reasons for preparing a plan document
- Suggest how the document should be organized
- Present a sample water management plan



WHY DO YOU NEED A WATER MANAGEMENT PLAN DOCUMENT?

There are many good reasons to prepare a document or report describing your water management plan, but the basic reason is so you can explain your plan to other people. Some of the other people who will need to understand your water management plan include:

- Members of the district Board of Directors who will need to approve the plan
- Members of the district staff who will need to implement the plan
- District water users who will want to know how the plan might affect them
- Agencies and lenders from whom the district might be seeking financing assistance
- Other local and regional water organizations with whom the district wishes to establish more cooperation
- Agencies from whom the district seeks permits or approvals
- Agencies and groups who may be unaware of the district's efforts to improve water management

For some of these people, the plan will be mainly an information document. But for others, the plan may be a "sales pitch" used to convince them of the wisdom of cooperating with the district, lending money to the district, etc. Especially in this latter case, the plan document will need to be prepared in a professional way, well-organized and complete, with easy to read text, tables, and figures.

Beyond being a description of what you want to do, putting your plan in writing means that you are making a commitment to do something. It puts the district on record as moving ahead to solve problems in a progressive way. This can be very important in dealing with potential future threats to district water rights and supplies from competing uses.

You will probably also find that the process of writing your plan down will help you see where it is deficient and could be improved.

SUGGESTED OUTLINE FOR THE PLAN DOCUMENT

Your water management plan document can be thought of as a compilation and synthesis of the information developed in Phases 1 through 5 of the planning process. A suggested outline for the plan document is provided below. Each outline item might be constructed as a separate chapter or section in your management plan.

Management Plan Document – Suggested Outline

I. Description of District

II. Inventory of Water Resources

III. District Water Budget

IV. Legal, Institutional, and Environmental Considerations

V. Existing Water Management Measures and Programs

VI. Issues and Goals

VII. Identification and Evaluation of Candidate Water Management Measures

  A. Identification of Candidate Water Management Measures

  B. Evaluation of Candidate Water Management Measures

VIII. Adopted Plan Elements

  A. Selected Measures

  B. Projected Results

  C. Implementation Schedule and Budget

  D. Monitoring Program

IX. Environmental Review

The objective of **Item I (Description of the District)** of the plan document is to provide sufficient background information on district organization, facilities, and operations so that your reader can understand the opportunities and constraints that exist for water management improvements in the district. This is especially important if your plan document is going to be read by people who are not familiar with the district, such as bankers or lending agencies.

It may not be necessary to write a lot of prose for this part of the document. Some of the information can be conveniently displayed in tabular form. You may also be able to incorporate existing materials, such as policies and organizational charts. Often, a simple paragraph will suffice.

A district map is also a good idea for an easy-to-read management plan document. The map should show facilities, canals, laterals, diversion points, measurement locations, pumping locations, seepage, drains and spill locations, and any identified problem areas.

In addition to those items, a comprehensive district description would include the following:

- District enabling legislation (formation authority) and governance
- Voting and taxing authorities
- Organizational structure and personnel
- Historical irrigated acreage and trends
- Historical population and trends

In summary, the plan should present a clear understanding of the district's particular circumstances within the context of its local setting (history, location, topography, climate, demographics, description of the distribution system, crops, soils, agricultural practices, etc.). The information contained here, along with information in Items II, III, and IV, provide the means for making a working assessment of the district's relevant issues.

Item II (Inventory of Water Resources) is documentation of the water resources inventory that you assembled in Step 1 of the planning process. Much of this information can be displayed in tables or graphs. On the district map, you should also indicate which portions of the delivery systems are unlined, which are lined, and which are piped.

Item III (District Water Budget) is your district water budget. The water budget should clearly depict where the district gets its water and how water is used and lost throughout the project. The budget should also provide sufficient information to identify potential water overuse, supply deficiencies, or system capacity problems. A suggested water budget format was provided in Section Two of this Guidebook. You may find that pie charts or other graphical display methods help you visualize the various components of district inflows and outflows.

Item IV (Legal, Institutional, and Environmental Considerations) is a discussion of any legal, institutional, and/or environmental considerations that place specific requirements or prohibitions on the district. Also, any environmental considerations that may impact the district's decision whether to implement specific water management activities or measures should be discussed as well.

Item V (Existing Water Management Measures and Programs) is a description of the district's current water management practices and programs. The plan should fully describe the water management programs currently being pursued by the district. It should suggest relative effectiveness of these programs. It could also discuss any activities that have been tried and later abandoned explaining the reasons for abandoning the activities.

Item VI (Issues and Goals) should be a brief but complete description of the apparent water management issues identified in Step 3 of the planning process. If any of the fundamental measures are not part of the current water management program, the lack of these measures should be included in the list of issues. Note that the conditions generating these issues should have been discussed in the first five sections of the plan. Where necessary, the issues should be prioritized so that the district and the reader can focus on the issues of greatest importance. Finally, the plan should also include your water management goal statements for each of the issues that the plan indicates are of concern to the district.

Item VII (Identification and Evaluation of Candidate Water Management Measures) should be a discussion of the evaluation you have made of candidate water management measures. The first part of this section should list all of the candidate measures (measures described in Section 3 of the Guidebook plus others not listed) that you consider could have potential to resolve each of the goals described above.

The second part of this section should contain a comparative evaluation of the candidate measures. The strengths and weaknesses of each candidate measure should be discussed in sufficient detail to support a decision whether to adopt each measure as part of the district's water management program. It would be appropriate to include a summary of the evaluation process and tabulations of any quantitative data analyses you conducted. In addition to the technical and financial evaluations, you may want to include a discussion of the legal, institutional, and environmental concerns that may be associated with the measures under consideration.

Item VIII (Adopted Plan Elements) should be a description of the elements (existing and new) that finally make up the water management plan you have adopted. The programs and measures that make up the plan should be described in detail, as should the expected effects and implications of those programs and measures. You should describe as clearly as possible how those measures will help you achieve your goals.

You should present a detailed schedule for implementing the plan. The schedule should be reasonable and achievable considering resources available to the District. There should also be a description of the budget and financing that will be required. This discussion should identify all resources (funds, staff, equipment, etc.) that would be required to implement the plan.

Finally, this section should discuss how implementation progress will be monitored and results evaluated. It should also describe the process for revising the district's water management plan based upon a periodic evaluation of program results.

Item IX (Environmental Review) identifies and evaluates the environmental effects (both positive and negative) of implementing the plan. It should also discuss the environmental compliance activities that will be required to implement specific elements of the plan. You may want to consult with Reclamation's local Water Conservation Coordinator for direction as this section is developed.

In most cases, it should be possible to incorporate into the plan document the tables and descriptions developed earlier in the planning process. It is also possible that some parts of the plan document can be created from available district documents and data summaries. We encourage you to use such resources in order to reduce the amount of effort required to complete your plan document.

An Example Water Management Plan for the hypothetical Springfield Irrigation District follows. This example is somewhat abbreviated for space reasons, but it should provide a useful example for you to follow in creating your own planning document.

SPRINGFIELD IRRIGATION DISTRICT WATER MANAGEMENT PLAN

DISTRICT DESCRIPTION

Springfield Irrigation District is a 10,000-acre irrigation district established in 1902. It diverts via the Springfield Canal below Spring Mountain Reservoir on the South Fork River (Figure 1).

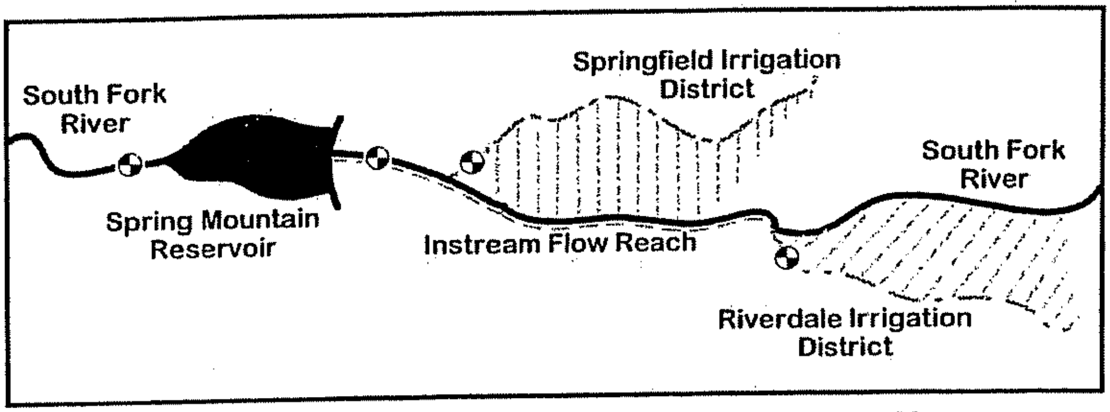


Figure 1: Springfield Irrigation District Location Map

The district is located in a semi-arid western climate, with a growing season adequate for forage, cereals, and some fruits and vegetables. The terrain is gently sloping and the soils in the district are loamy with some stony, shallow sections. Springfield currently has 55 farms. Crops grown in the district are primarily alfalfa (4,000 acres), grass hay (5,000 acres) and corn (1,000 acres). Irrigation methods are mostly flood and contour ditch with some siphon tubes for row crops.
The Springfield Canal and its laterals are unlined. There are 11 miles of laterals, 9 miles of main canal and 16 miles of open drains. The canal was originally constructed in 1902, but there have been several improvements and some realignment since then. The canal headworks consist of a concrete wall with two radial gates, installed in 1957. Most of the district's headgates, valves, checks, and drop structures are at least 30 years old.

The Springfield Canal is usually run full to ensure deliveries to farmers at the lower end of the district. There are a few tailwater ponds and drainage ditches to facilitate reuse. Seepage from the canal has resulted in establishment of wetlands along the canal.

The district has a Board of Directors elected by the shareholders. The three-member board is made up of district farmers, each serving 3-year terms. The district staff includes a District Manager, a secretary, and two ditch riders. District revenues are based on per-acre assessments. Every farmer in the district pays assessments based on the number of acres he or she owns. The district uses these assessments to fund operations and capital improvements.

Springfield has both a natural flow water right and a supplemental supply contract with Reclamation for storage water in Spring Mountain Reservoir. Storage water releases are requested by Springfield through an ordering process established between the district and Reclamation.

INVENTORY OF WATER RESOURCES

Springfield has a 1902 natural flow water right on the South Fork for 180 cfs. Streamflows in the South Fork are highly dependent on the previous winter's snowpack and Springfield's water right rarely yields sufficient water for irrigation in late-season months. In 1956, Springfield contracted with Reclamation for 16,000 acre-feet of supplemental supply from Spring Mountain Reservoir. Average monthly diversions of natural flow and storage water by the district are shown in Table 1. The district does not have any groundwater supplies.

Table 1
Springfield Irrigation District
Average Monthly Storage and Natural Flow Diversions

	Natural Flow, af	Storage Flow, af	Total, af
April	6,427	0	6,427
May	11,068	0	11,068
June	10,711	0	10,711
July	6,149	4,919	11,068
August	664	5,977	6,641
September	166	3,154	3,320
October	43	1,242	1,285
Total	35,227	15,293	50,520

The water quality of Springfield's sources is high but its return flows and drainage have excessive sediment and nutrients, especially in the early season.

WATER BUDGET

A district water budget was developed to help identify water supply and timing problems and opportunities. Diversion, loss, and delivery data are regularly submitted to Reclamation, though only diversion data are actually measured (Table 2). Without actual measurements, the loss data submitted have been based on a combination of estimates of farm deliveries and a report of transportation losses done by Reclamation and the district about 25 years ago. Delivery data have traditionally been estimated by ditch riders and farmers, based on numbers of applications and judgment. Though operational spills are known to occur, there have been no measurements or estimates made.

Table 2
Springfield Irrigation District
Water Data Submitted to Reclamation
1965-1995 Average

	Net Supply, af*	Operational Spills, af	Transportation Losses, af	Delivered to Farms, af	Acre-feet per Acre
April	6,427	0	1,607	4,820	0.48
May	11,068	0	2,214	8,854	0.89
June	10,711	0	1,607	9,104	0.91
July	11,068	0	1,328	9,740	0.97
August	6,641	0	797	5,844	0.58
September	3,320	0	398	2,922	0.29
October	1,285	0	154	1,131	0.11
Total	50,520	0	8,105	42,415	4.00

* Combines project water and nonproject water

Since the district's loss and delivery data are not verifiable for this water budget, an approach was taken to rely more heavily on the measured data: the main canal diversions. These diversions were compared to crop water requirements obtained from the county extension agent. Calculations of crop requirements for Springfield Irrigation District are shown in Table 3. Overall, the average annual crop water requirement for the district is approximately 18,500 acre-feet. The monthly distribution of crop requirements is illustrated in Figure 2.

Table 3
Springfield Irrigation District
Average Monthly Crop Water Requirements

	Corn	**Alfalfa**	**Grass**	
Acres	1,000	4,000	5,000	
	Crop Rqmt, in	Crop Rqmt, in	Crop Rqmt, in	**Total Crop Rqmt, af**
April	0.0	0.0	1.3	542
May	0.6	3.1	2.6	2,144
June	2.2	4.7	3.7	3,309
July	6.1	7.1	5.9	5,318
August	5.9	5.9	5.0	4,518
September	1.5	3.0	2.7	2,249
October	0.0	0.2	0.7	377
Total	16.3	24.0	21.8	18,458

Using the crop requirements, the canal diversion data and the estimated transportation losses, overall farm efficiency was calculated (*farm efficiency = crop requirement÷delivery*). These calculations gave an overall, annual farm efficiency of 44 percent (Table 4). If the transportation loss values are accurate, then the overall farm efficiency fluctuates from 11 to 77 percent during the irrigation season (Figure 3). This enormous range in farm efficiency suggests an unlikely situation, where farms are literally flooded in spring. It is more likely that the transportation loss value is incorrect and that there are other types of losses, like operational spills, taking place, especially early in the season.

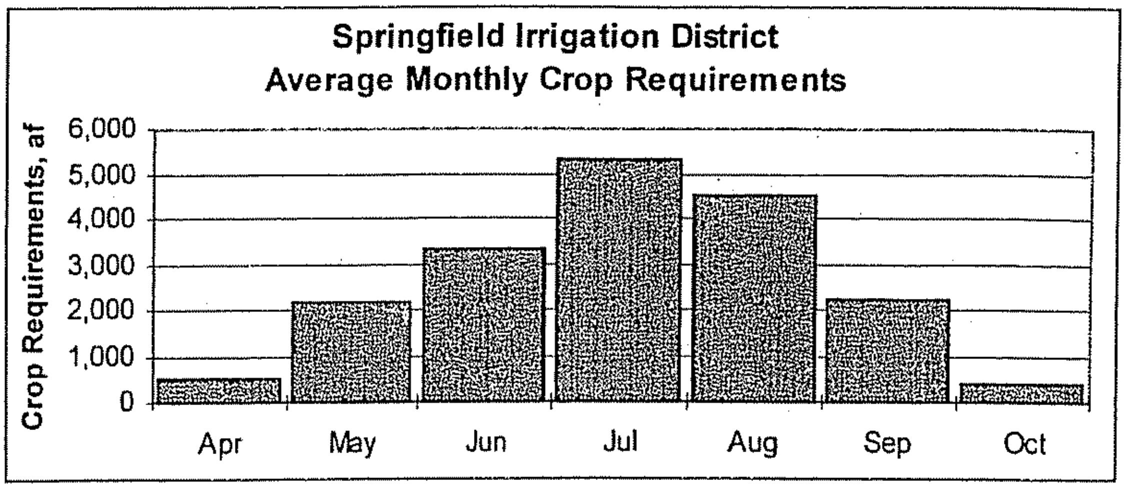


Figure 2: District-wide Average Monthly Crop Requirements

Table 4
Springfield Irrigation District
Average Monthly Farm Efficiency Calculation

	Average Canal Diversion, af	Delivered to Farms, af	Total Crop Requirement, af	Farm Efficiency
April	6,427	4,820	542	0.11
May	11,068	8,854	2,144	0.24
June	10,711	9,104	3,309	0.36
July	11,068	9,740	5,318	0.55
August	6,641	5,844	4,518	0.77
September	3,320	2,922	2,249	0.77
October	1,285	1,131	377	0.33
Total	50,520	42,415	18,458	0.44

To better understand the system losses, an overall district-wide efficiency, which reflects all losses to seepage, spills and other kinds of waste, was calculated (*overall efficiency = crop requirement÷canal diversion*). Annually, for Springfield, the average overall efficiency value is 37percent (Table 5). Spring efficiencies are as low as 8 percent, suggesting that there are substantial early-season losses or waste.

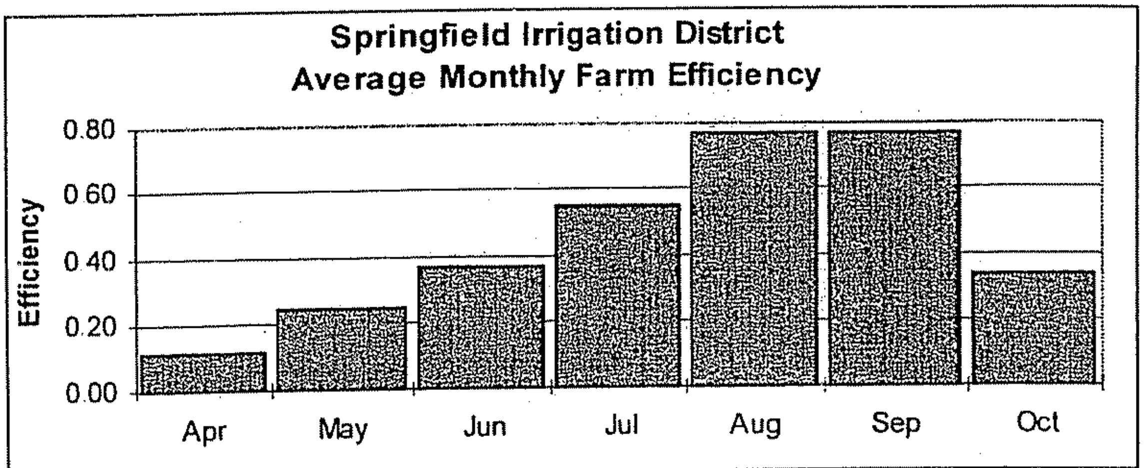


Figure 3: Overall District-wide Farm Efficiency

Table 5 Springfield Irrigation District Overall Efficiency Calculation			
	Canal Diversion, af	Total Crop Requirement, af	Overall Efficiency
April	6,427	542	0.08
May	11,068	2,144	0.19
June	10,711	3,309	0.31
July	11,068	5,318	0.48
August	6,641	4,518	0.68
September	3,320	2,249	0.68
October	1,285	377	0.29
Total	50,520	18,458	0.37

Finally, district-wide diversion requirements were calculated to get a picture of the match between diversion requirements and actual diversions (Table 6 and Figure 4).

Table 6 Springfield Irrigation District Average Monthly Diversion Requirement		
	Total Crop Requirement, af	**Diversion Requirement, af***
April	542	1,083
May	2,144	4,288
June	3,309	6,618
July	5,318	10,637
August	4,518	9,037
September	2,249	4,498
October	377	753
Total	18,458	36,915

*Assumes 50% overall efficiency

These estimates are based on an assumption that 200 percent of the crop water requirement must be diverted to fulfill the entire district's water requirement. This assumption was based on efficiency tables in the state's irrigation guide. For soils, slopes and irrigation methods common to Springfield, an overall irrigation efficiency of 50 percent is reasonable.

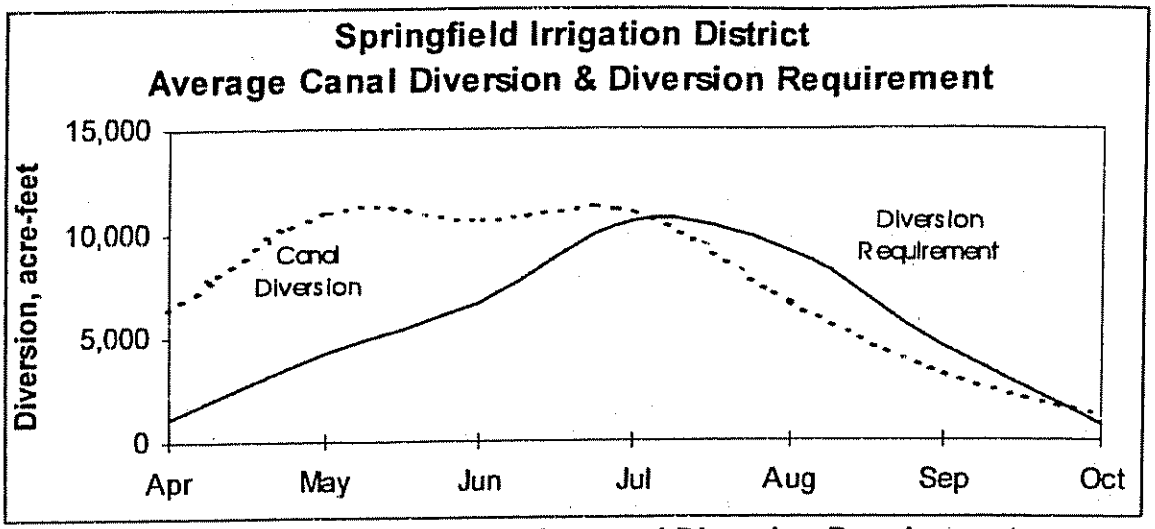


Figure 4 District-wide Diversions and Diversion Requirements

The following conclusions were made from the water budget analysis:

- Overall, average district-wide efficiency is 0.37 percent
- Approximately 32,000 acre-feet of diversion goes unused by crops in an average year
- Historical farm delivery estimates are probably incorrect
- The district is diverting too much water in the early season. This is likely the result of habit and conservatism on the part of both the district and its irrigators
- Early-season excess natural flow diversions may be competing with junior storage rights at Spring Mountain Reservoir, possibly jeopardizing late-season storage supplies
- Wetlands and drainage problems are likely evidence of excessive losses and spills in the early season
- The water budget needs to be revisited and revised as better data becomes available

EXISTING WATER MANAGEMENT MEASURES AND PROGRAMS

Springfield does not have formal water management measures and programs. The district has historically operated by diverting to its capacity when natural flow water was available under its water right. Each season, as Springfield runs out of natural flow water, it begins ordering storage water from Reclamation. The district has made water conservation materials available to its farmers whenever they are supplied by the county, state, Reclamation, or NRCS. Some of the district farmers have been able to convert to using gated pipe.

LEGAL, INSTITUTIONAL, AND ENVIRONMENTAL CONSIDERATIONS

Springfield's water rights are established by state law and by contract with Reclamation. There are no unusual requirements that would impact the water supply.

Springfield's policies govern the operation of the project. It has been noted that farmers are allowed to partially control water deliveries to their farms. As a result, substantial spills have been noted when farmers shut off water to their laterals without making sufficient arrangements for another farmer to use the water or for main canal diversions to be reduced.

There are two main environmental concerns. The quality of district drainage and return flows impacts the downstream quality of water. This can have impacts on both the natural habitat and M&I users downstream. Wetlands have been created by seepage from Springfield's canals. Some of these wetlands are important migratory bird habitat.

ISSUES AND GOALS

The water budget analysis helped to identify several key issues. First, there is a significant mismatch between the timing of crop irrigation requirements and diversions by the Springfield Canal. Second, there are substantial, unexplained losses in the early season, and third, there is insufficient data to clearly determine where and how losses are occurring. The water budget analysis did reveal, however, that on an annual basis there is probably enough water to meet the district's irrigation demands.

In addition to the water budget analysis, extensive discussions were held with district irrigators and community representatives to determine the key issues the district, its farmers, and its neighbors were facing. These discussions identified many issues. Through an iterative process of examination and re-examination, it became apparent that some of the issues were really sub-issues of more basic underlying issues. An examination of the issues allowed the district to prioritize the identified issues. Table 7 lists the issues identified by the district.

Table 7
Springfield Irrigation District
Prioritized Issues

Priority	Issue	Comments
1	Farm deliveries and operational spills are not measured: A. Farmers cannot match deliveries to crop requirements B. Water budget contains significant inaccuracies C. District cannot bill for water used	Water cannot be managed and used efficiently without adequate measurement.
2	Excessive early-season diversions reduce availability of late-season supplies: A. Water supply is insufficient in late-season months B. Farm efficiencies are low in early season C. Overall efficiency is low in early season D. Seasonal diversions do not match seasonal crop use E. Early-season diversions impact junior storage rights F. Return flows have excessive sediment and nutrients G. Low, late-season reservoir levels detract from recreation	Poor early-season efficiencies need to be corrected in order to have adequate late-season water supplies. Other efforts are meaningless without adequate late-season supplies.
3	Per-acre assessments encourage water waste and produce inequitable water costs between efficient and inefficient users.	Financial incentives are necessary to encourage efficient water use.
4	Canal spills often occur when farmers shut off their laterals.	This needs to be addressed to reduce unnecessary water waste.
5	Deliveries to the lower end of the district are frequently insufficient when compared to the upper end.	This may be caused by capacity problems or excessive use by some farmers.
6	State wants increased flows in river below district's diversion.	This is a serious concern but may be addressed by resolution of Issue #2
7	Quality of drainage and return flows concern downstream M&I users.	Resolution of Issue #2 could help resolve this issue.
8	Portions of canal have excessive seepage losses.	Resolution could be complex and lengthy.
9	Seepage supports wetlands that provide migratory bird habitat.	This is recognized as a possible constraint on other activities.

Once the basic issues were understood, the district defined its goals for the water management plan. The district choose to focus its attention on the top seven issues. Again, development of the district's goals was an iterative process, requiring discussions with irrigators and the community. Through this iterative process, it became apparent that these problems and symptoms were related to how the district managed water deliveries and how the district worked with other South Fork basin water users. Springfield's board of directors ultimately identified the goals shown in Table 8.

Table 8 Springfield Irrigation District Water Management Goals		
Priority	**Issue**	**Goal**
1	Farm deliveries and operation spills are not measured.	All farm deliveries and operational spills greater than 0.25 acre-foot will be measured within 3 years.
2	Early-season diversions are excessive and late-season shortages exist.	Beginning next irrigation season, match diversions to actual crop requirements so that unneeded natural flows can be stored in the reservoir.
3	Per-acre assessments encourage water waste and produce inequitable water costs between efficient and inefficient users.	In 3 years, water bills will include a component based upon water use.
4	Canal spills often occur when farmers shut off their laterals.	Delivery flows will not be changed without advance approval of the district.
5	Deliveries to the lower end of the district are frequently insufficient when compared to the upper end.	Within 1 year, the district will have a plan for equitably distributing water between the upper and lower ends of the district.
6	The State wants increased flows in river below district's diversion	Provide 20 percent of anticipated diversion reduction as a in-stream flow below the diversion The remainder will be stored for later release.
7	Quality of drainage and return flows concern downstream M&I users.	Achievement of the above goals should resolve this issue.

IDENTIFICATION AND EVALUATION OF CANDIDATE WATER MANAGEMENT MEASURES

There are numerous water management measures that accomplish a wide range of goals. However, only a limited few have the capacity to accomplish the specific goals stated above. Table 9 shows those candidate measures that have the capacity to help achieve the stated goals. In identifying candidate measures, special attention was given to the serious mismatch between efficiencies achieved in the early-season and late season. We concluded that major system improvements or modifications other than improved water measurement would not resolve the issue. Rather, attention needed to be directed to those management activities that would reduce early season diversions and make additional water available later in the season. Diversions, especially early-season diversions, must be based upon actual needs rather than available supply as has been the case in the past.

Comparison of candidate water management measures are listed in Tables 10 and 11. Measures were evaluated from both a technical standpoint and a legal, institutional, and environmental standpoint.

Table 9 Springfield Irrigation District Candidate Water Management Measures		
Priority	**Goal**	**Candidate Measures**
1	All farm deliveries and operational spills greater than 0.25 acre-foot will be measured within 3 years.	Install measuring devices at all farm turnouts and spills, one-third each year.
2	Beginning next irrigation season, match diversions to actual crop requirements so that unneeded natural flows can be stored in the reservoir.	A. Change policy to require 2-day advance ordering of water. B. Implement field-by-field irrigation scheduling C. Publish daily crop consumptive use information D. Educate farmers on proper irrigation techniques E. Install sprinkler systems F. Install reuse collector systems
3	In 3 years, water bills will include a component based upon water use.	A. Measure deliveries to all farm turnouts B. Develop and institute an incentive pricing rate structure C. Implement computerized water billing D. Educate farmers on implications of incentive pricing
4	Delivery flows will not be changed without advance approval of the district.	A. Ditchriders make all delivery flow changes B. Farmers obtain prior approval to make flow changes with penalty for failure to comply
5	Within one year, the district will have a plan for equitably distributing water between the upper and lower ends of the district.	Obtain technical assistance to determine reason(s) for inequitable distribution of water and then develop plan.
6	Provide 20 percent of anticipated diversion reduction as a in-stream flow below the diversion. The remainder will be stored for later release.	Negotiate an agreement with State and Reclamation describing how in-stream flows would be determined and managed.

Technical Evaluation

The technical evaluation examined the measures from a feasibility and cost standpoint. Estimates of water supply and cost effects of 12 potential water management measures were made with assistance from Reclamation, NRCS, and extension service personnel. Irrigation districts that have implemented some of the measures were also contacted to collect data on effects. Results of the investigations are summarized in Table 10. In the table, water supply "amount," "efficiency," and "equity" refer to the effects of the measure on district supplies, efficiency of water use, and fairness of water service within the district, respectively. "No change" indicates that the measure is not likely to have an effect in that category. A plus sign indicates an increase, a negative sign means a decrease, and a question mark indicates that the effect has not been predicted or is unclear. Annualized costs include both construction, operation, and maintenance costs.

Measures that were evaluated in detail include water measurement, incentive pricing, various policy changes, irrigation scheduling, and education. Incentive pricing had very low construction costs but relatively high operating costs. In the short-term, incentive pricing was not expected to increase overall water supply but it was expected to cause a redistribution of existing supplies away from inefficient water users to more efficient water users. In the long-term, it was expected to increase overall district efficiency. An incentive pricing system could also provide some additional funds to establish a revolving loan fund. The loan fund could help finance on-farm efficiency improvements such as conversion to sprinkler or drip irrigation.

Irrigation scheduling had relatively low initial costs and relatively high operating costs. The measure was not expected to increase overall supplies for the district. Over the long-term, it was expected to increase crop quality and quantity and provide more flexibility to district farmers.

As an alternative to field-by-field irrigation scheduling, the district considered publishing daily crop consumptive use data. This would give district farmers more information to improve the way they schedule irrigations and order water. An aggressive education program would be required to educate the farmers in the proper use of the published data.

Education programs were the least expensive measures investigated. They would have little short-term effect on water supply or water use efficiency. Effects would be seen over the long-term, as district irrigators adopted the suggested practices and facilities.

Legal, Institutional, and Environmental Evaluation

Discussions were also held with Springfield's attorneys, Reclamation personnel, the State engineer's office, and the State environmental office to assess potential legal, institutional, and environmental issues that might be associated with the water management measures.

Results of those investigations are summarized in Table 11. Again, the measures investigated in detail include water measurement, incentive pricing, irrigation scheduling, policy changes, and education programs. Water measurement is unlikely to have any federal or state issues associated with it. There could be some local resistance on the part of district farmers because it represents a change in long-standing practices. It will also require additional training for ditchriders and changes in operating practices. Typically, a reaction to implementation of water measurement is a small reduction of water applied. This could result in some reduced drainage. Impacts to wetlands would probably be insignificant.

Table 10
Candidate Water Management Measures
Technical Evaluation

Candidate Measures	Issues Addressed	Effects			
		Water Supply			Annualized Cost
		Amount	Efficiency	Equity	$/yr
Water Measurement	1,2,3,7	no change	+	+	25,000[1]
Ordering Policy	2,7	match div. to demand	+	+	5,000
Irrigation Scheduling	2,7	match div. to demand	+	+	20,000
Publish Crop Use Data	2,7	match div. to demand	+	+	1,000
Sprinkler Installation	2,7	reduce demand	+	?	194,000
Reuse Systems	2,7	reduce demand	+	?	225,000
Incentive Pricing and computer billing	3,7	reduce demand	+	+	10,000
Ditchriders change flows	4,7	no change	+	+	2,000
Farmers change flows	4	no change	+	-	-
Study water distribution equity	5,7	no change	?	+	20,000
In-stream flow agreement	6	no change	?	?	?
Education	2,3,7	may reduce demand	+	+	1,200

[1]First 3 years then 2,000 per year thereafter.

Incentive pricing was considered unlikely to have federal or local issues associated with it, but there may be some restrictions under state law that limit Springfield's flexibility to implement the measure. Incentive pricing, if it encourages water use efficiency, was expected to reduce drainage. Impacts to wetlands supported by the main canal are unknown.

Irrigation scheduling was not expected to have federal, state or local implications, though there may be effects to the wetlands supported by the main canal. Again, drainage from the district was expected to decrease with irrigation scheduling.

Education programs were not expected to have legal or institutional issues associated with them.

ADOPTED PLAN ELEMENTS

Selected Measures

Measures that were eliminated without detailed investigation were those that involved expensive construction projects. Measures that were selected to be examined in detail were those that helped to achieve the goals of the district without being too costly.

Measures considered too costly at this time included field-by-field irrigation scheduling, sprinkler system installation, and reuse systems.

The final water management plan has three programs: a water measurement and billing program, an irrigation scheduling program, and an education program. In addition, the plan will include several policy changes and studies. After evaluation, these three programs were considered as having the most potential, within reasonable costs, to achieving Springfield's goals of improving the district's water delivery service and of providing leadership in the South Fork basin.

Table 11
Candidate Water Management Measures
Legal, Institutional, and Environmental Evaluation

Alternatives	Issues					
	Institutional			Legal	Environmental	
	Federal	State	Local	Water Rights	Drainage	Wetlands
Water Measurement	none	none	none	none	-	?
Ordering Policy	none	none	none	none	-	?
Irrigation Scheduling	none	none	none	none	-	?
Publish Crop Data	none	none	none	none	-	?
Sprinkler Installation	none	none	none	none	-	?
Reuse Systems	none	none	none	none	-	?
Incentive Pricing	none	possible	none	none	-	?

Table 11
Candidate Water Management Measures
Legal, Institutional, and Environmental Evaluation

Ditchriders Change Flows	none	none	none	none	-	?
Farmers Change Flows	none	none	none	none	-	?
Study Water Distribution Equity	none	none	none	none	-	?
In-stream Flow Agreement	possible	possible	none	possible	?	?
Education	none	none	none	none	?	?

Water Measurement and Billing Program

The measurement portion of the program will include installation of 16 flumes and weirs per year to measure flows at turnouts. All turnouts are expected to be measured by the end of the third year. The program also includes adding eight staff gauges at drains and wasteways to help identify locations and amounts of losses, spills, and other waste. During the time that measuring devices are being installed, a computer accounting system will be implemented. An incentive pricing rate structure will be developed and ready for implementation at the beginning of the fourth year.

Irrigation Scheduling Program

The irrigation scheduling program can be implemented with technical assistance from the county extension agent. She has agreed to calculate and transmit daily evapotranspiration and effective precipitation data to the local newspaper each day. With the ability of district farmers to predict when irrigation events are required, new policies will require farmers to order water 2 days in advance of need. This will allow Springfield to more accurately schedule diversions from the South Fork. Reclamation has committed to working with Springfield to better conserve springtime flows for recreation and late season irrigation use.

Education Program

The education program will focus on training farmers in the proper techniques of irrigation scheduling. It will also prepare farmers for implementation of incentive pricing. Other activities will include mobile demonstration projects. The demonstration projects will include movable surge valves and gated pipes.

Other Program Activities

Springfield will issue new operational policies that require farmers to obtain permission from the district before making any changes in delivery flows. If the change in policy does not prove satisfactory, the district is prepared to require that all flow changes be made by ditch riders. The district will begin to collect data to define the distribution inequities between the upper and lower ends of the district. The district expects that some early-season natural flows may be available once the water management plan is implemented. The district will begin discussions with the State and Reclamation to determine an acceptable minimum in-stream flow below the district's diversion on South Fork.

Projected Results

Improved water measurement is expected to improve overall water management, both within the district and on the farm. Irrigation scheduling is expected to ultimately reduce early season diversions by approximately 16,000 acre-feet and to increase late season diversions by about 4,000 acre-feet. Early season drainage problems are projected to be reduced at a level of magnitude similar to the reduction in early season diversion. Additional reductions in diversion may occur when the incentive pricing program is implemented and the revolving loan fund becomes operational.

Canal maintenance requirements are expected to be lower because of lower flows in the early season. Service to district irrigators will improve with better timing of deliveries and more late-season water. Other South Fork basin water users will benefit by higher water levels in Spring Mountain Reservoir and improved quality of drainage and return flows.

Irrigation scheduling, education programs, and measuring devices do not directly address the problems of inadequate deliveries to the lower end of the district. Possible impacts to those irrigators may be positive or negative. The situation for irrigators at the lower end of the system may improve if irrigators at the upper end actively participate in irrigation scheduling and reduce their demands. The situation may deteriorate if irrigation scheduling results in higher demands during peak periods, further stressing the canal. Because so little is understood about the locations and amounts of losses in the system, the district is hesitant to engage in a major construction effort to increase the canal capacity or arbitrarily line sections of the canal. However, after measuring devices have been installed, the causes of the delivery problems will be more clear. It may be that the next management plan recommends construction projects as the most cost-effective solutions.

Implementation Schedule and Budget

An implementation schedule and budget for the water management plan are summarized in Table 12.

Table 12
Springfield Irrigation District
Implementation Schedule and Budget

Activity	Scheduled Start	Budget
Publish ET and effective precipitation information	Beginning of this irrigation season	$2,000
Coordinate new ordering system with Reclamation	Immediately	$1,000
Demonstration programs	Next season	$5,000
Install measuring devices at turnouts, 16 per year	Begin now, finish in 3 years	$16,000/yr
Install staff gauges at drains and wasteways	This season	$1,200

Monitoring

A monitoring program is essential to determine the effectiveness of the new program. It will also be key to identifying opportunities for further management improvements. Monitoring efforts will include:

- Data collection from gauges installed at turnouts
- Data collection from new staff gauges on wasteways and drains
- Periodic collection of feedback from district irrigators
- Periodic comparison of crop requirement estimates with diversions
- Periodic inspection of canal conditions
- Periodic evaluation of selected program's fulfilment of Springfield's goals

At least annually, district staff will review the data gathered to determine if goals are being met. Where necessary, they will refine issues and goals, add or delete measures, adjust schedules, or refine budgets. The entire plan will be updated in 5 years.

ENVIRONMENTAL REVIEW

Some positive benefits are expected from implementation of this plan. Some additional in-stream flows are expected below the district's diversion on South Fork and drainage flows are expected to be reduced. This should improve the quality of flows for downstream habitat and other water users. No major canal lining projects are planned at this time so there should not be major impacts to wetlands.

Most components of the plan can be implemented without extensive environmental compliance activities. The one exception may involve completion of an in-stream flow agreement. Reclamation's participation in the agreement would constitute a federal action and would trigger the need for environmental compliance activities.

Glossary

Glossary

Acre-foot: A volume of water that would cover one acre to a depth of one foot, or 325,850 gallons of water.

Application efficiency: The ratio of the average depth of irrigation water infiltrated and stored in the root zone to the average depth of irrigation water applied, expressed as a percent.

Applied water: Water delivered to a user. Also called delivered water. Applied water may be used for either inside uses or outside watering. It does not include precipitation or distribution losses. It may apply to metered or unmetered deliveries.

Aquifer: Underground water-bearing geologic formation or structure.

Arable: Having soil or topographic features suitable for cultivation.

Artificial drains: Man-made or constructed drains.

Available capacity: The amount of water held in the soil that is available to the plants.

Check dam: Small barrier constructed in a gully or other small watercourse to decrease flow velocity, minimize channel scour, and promote deposition of sediment.

Conduit: Any open or closed channel intended for the conveyance of water.

Conjunctive use: The coordinated use of surface water and groundwater resources.

Conservation: Increasing the efficiency of energy use, water use, production, or distribution.

Consumptive use (evapotranspiration): Combined amounts of water needed for transpiration by vegetation and for evaporation from adjacent soil, snow, or intercepted precipitation. Also called: Crop requirement, crop irrigation requirement, consumptive use requirement.

Continuous-flow irrigation: System of irrigation water delivery where each irrigator receives his allotted quantity of water at a continuous rate.

Contour ditch: Irrigation ditch laid out approximately on the contour.

Contour farming: System of farming used for erosion control and moisture conservation whereby field operations are performed approximately on the contour.

Contour flooding: Method of irrigation by flooding from contour ditches.

Contour furrows: Furrows plowed approximately on the contour on pasture or rangeland to prevent soil loss and increase infiltration. Also furrows laid out on the contour for irrigation purposes.

Control structure: Water regulating structure, usually for open conduits.

Conveyance loss: Loss of water from a channel or pipe during conveyance, including losses due to seepage, leakage, evaporation and transpiration by plants growing in or near the channel.

Conveyance system efficiency: The ratio of the volume of water delivered to users in proportion to the volume of water introduced into the conveyance system.

Critical habitat: Areas that contain essential habitat features important for the conservation of a species. Designated critical habitat may require special management or protection under Section 7 of the Endangered Species Act.

Crop irrigation requirement: Quantity of water, exclusive of effective precipitation, that is needed for crop production.

Crop root zone: The soil depth from which a mature crop extracts most of the water needed for evapotranspiration. The crop root zone is equal to effective rooting depth and is expressed as a depth in inches or feet. This soil depth may be considered as the rooting depth of a subsequent crop, when accounting for soil moisture storage in efficiency calculations.

Cropping pattern: The acreage distribution of different crops in any one year in a given farm area such as a county, water agency, or farm. Thus, a change in a cropping pattern from one year to the next can occur by changing the relative acreage of existing crops, and/or by introducing new crops, and/or by cropping existing crops.

Crop water requirement: Crop consumptive use plus the water required to provide the leaching requirements.

Cubic feet per second (ft^3/s): A rate of streamflow; the volume, in cubic feet, of water passing a reference point in 1 second.

Deep percolation: The movement of water by gravity downward through the soil profile beyond the root zone; this water is not used by plants.

Demand scheduling: Method of irrigation scheduling whereby water is delivered to users as needed and which may vary in flow rate, frequency, and duration. Considered a flexible form of scheduling.

Distribution efficiency: Measure of the uniformity of irrigation water distribution over a field.

Distribution loss: See conveyance loss.

Distribution system: System of ditches, or conduits and their appurtenances, which conveys irrigation water from the main canal to the farm units.

District: An entity that has a contract with the Reclamation for the delivery of irrigation water. Such entities include, but are not limited to: canal companies; conservancy districts, ditch companies, irrigation and drainage districts, irrigation companies, irrigation districts, reclamation districts, service districts, storage districts, water districts, and water users associations.

Ditch: Constructed open channel for conducting water. See canal, drain.

Diversion (water): Removal of water from its natural channels for human use.

Diversion (structure): Channel constructed across the slope for the purpose of intercepting surface runoff; changing the accustomed course of all or part of a stream.

Drainage: Process of removing surface or subsurface water from a soil or area.

Drainage system: Collection of surface and/or subsurface drains, together with structures and pumps, used to remove surface or groundwater.

Drip (trickle) irrigation: An irrigation method in which water is delivered to, or near, each plant in small-diameter plastic tubing. The water is then discharged at a rate less than the soil infiltration capacity through pores, perforations, or small emitters on the tubing. The tubing may be laid on the soil surface, be shallowly buried, or be supported above the surface (as on grape trellises).

Drought: Climatic condition in which there is insufficient soil moisture available for normal vegetative growth.

Erosion: A gradual wearing away of soil or rock by running water, waves, or wind.

Evaporation: Water vapor losses from water surfaces, sprinkler irrigation, and other related factors.

Evapotranspiration: The quantity of water transpired by plants or evaporated from adjacent soil surfaces in a specific time period. Usually expressed in depth of water per unit area.

Fallow: Land plowed, tilled, and left unplanted.

Farm consumptive use: Water consumptively used by an entire farm, excluding domestic use. See irrigation requirement, consumptive use, evapotranspiration.

Farm distribution system: Ditches, pipelines and appurtenant structures which constitute the means of conveying irrigation water from a farm turnout to the fields to be irrigated.

Farm loss (water): Water delivered to a farm which is not made available to the crop to be irrigated.

Field capacity: Depth of water retained in the soil after ample irrigation or heavy rain when the rate of downward movement has substantially decreased, usually 1 to 3 days after irrigation or rain, expressed as a depth of water in inches or feet. Also called field moisture capacity.

Fixed amount-frequency scheduling: Method of irrigation scheduling that involves water delivery at a fixed rate or a fixed volume and at constant intervals. Examples include rotation and continuous flow methods. Considered a rigid form of scheduling.

Flood control pool: Reservoir volume reserved for flood runoff and then evacuated as soon as possible to keep that volume in readiness for the next flood.

Flood irrigation: Method of irrigating where water is applied from field ditches onto land which has no guide preparation such as furrows, borders, or corrugations.

Frequency demand scheduling: Method of irrigation scheduling similar to demand scheduling, but typically involves a fixed duration of the delivery, such as 24 hours. This method is considered flexible, although somewhat less so than demand scheduling from the water users perspective.

Gate (irrigation): Structure or device for controlling the rate of flow into or from a canal or ditch.

Gated pipe: Portable pipe with small gates installed along one side for distributing irrigation water to corrugations or furrows.

Gauge: Device for registering water level, discharge, velocity, pressure, etc.

Gauge height: Elevation of water surface measured by a gauge.

Gauging station: Specific location on a stream where systematic observations of hydrologic data are obtained through mechanical or electrical means.

Gravity irrigation: Irrigation method that applies irrigation water to fields by letting it flow from a higher level supply canal through ditches or furrows to fields at a lower level.

Groundwater: (1) Water that flows or seeps downward and saturates soil or rock, supplying springs and wells. The upper level of the saturated zone is called the water table. (2) Water stored underground in rock crevices and in the pores of geologic materials that make up the earth's crust. That part of the subsurface water which is in the zone of saturation; phreatic water.

Groundwater mining (overdraft): Pumping of groundwater for irrigation or other uses, at rates faster than the rate at which the groundwater is being recharged.

Groundwater recharge: The flow to groundwater storage from precipitation, infiltration from streams, and other sources of water.

Groundwater table: The upper boundary of groundwater where water pressure is equal to atmospheric pressure, i.e., water level in a bore hole after equilibrium when groundwater can freely enter the hole from the sides and bottom.

Growing season: The period, often the frost-free period, during which the climate is such that crops can be produced.

Hydraulic efficiency: Efficiency of a pump or turbine to impart energy to or extract energy from water. The ability of hydraulic structure or element to conduct water with minimum energy loss.

Hydrology: Science dealing with the properties, distribution and flow of water on or in the earth.

Infiltration rate: The rate of water entry into the soil expressed as a depth of water per unit of time in inches per hour or feet per day. The infiltration rate changes with time during irrigation.

Instream flows: Water flows for uses within a defined stream channel, e.g., flows intended for fish and wildlife.

Irrigated acreage: Irrigable acreage actually irrigated in any 1 year. It includes irrigated cropland harvested, irrigated pasture, cropland planted but not harvested, and the acreage in irrigation rotation used for soil building crops.

Irrigation: Application of water to lands for agricultural purposes.

Irrigation check: Small dike or dam used in the furrow alongside an irrigation border to make the water spread evenly across the border.

Irrigation efficiency: The ratio of the average depth of irrigation water that is beneficially used to the average depth of irrigation water applied, expressed as a percent. Beneficial uses include satisfying the soil water deficit and any leaching requirement to remove salts from the root zone.

Irrigation frequency: Time interval between irrigations.

Irrigation requirement: Quantity of water, exclusive of effective precipitation, that is required for crop production.

Land classification: Reclamation's systematic placing of lands into classes based on their suitability for sustained irrigated farming. Land classes are defined by productivity, with class 1 being the most productive. For other classes, the equivalent acreage to class 1 for the same productivity is defined (class 1 equivalency).

Land leveling: Process of shaping the land surface for better movement of water and machinery over the land. Also called land forming, land shaping, or land grading.

Land retirement: Permanent removal of land from agricultural production.

Land-use planning: Development of plans for the use of land that will, over a long period, best serve the general public.

Leaching: Removal of soluble material from soil or other permeable material by the passage of water through it.

Leaching requirement: Quantity of irrigation water required for transporting salts through the soil profile to maintain a favorable salt balance in the root zone for plant development.

Lining: Protective covering over the perimeter of a conduit, reservoir, or channel to prevent seepage losses, to withstand pressure, or to resist erosion.

Lysimeter: An isolated block of soil, usually undisturbed and in situ, for measuring the quantity, quality, or rate of water movement through or from the soil.

Neutron probe: An instrument used to estimate soil moisture. Relates the rate of attenuation in pulsed neutron emissions to soil water content.

Nonconsumptive water uses: Water uses that do not substantially deplete water supplies, including swimming, boating, water-skiing, fishing, maintaining stream related fish and wildlife habitat, and generating hydropower.

On-farm: Activities (especially growing crops and applying irrigation water) that occur within the legal boundaries of private property.

On-farm irrigation efficiency: The ratio of the volume of water used for consumptive use and leaching requirements in cropped areas to the volume of water delivered to a farm (applied water).

Operational losses: Losses of water resulting from evaporation, seepage, and spills.

Operational waste: Water that is lost or otherwise discarded from an irrigation system after having been diverted into it as part of normal operations.

Pan evaporation: Evaporative water losses from a standardized pan. Pan evaporation is sometimes used to estimate crop evapotranspiration and assist in irrigation scheduling.

Parshall flume: A calibrated device, based on the principle of critical flow, used to measure the flow of water in open conduits. Formerly termed the Improved Venturi Flume.

Percolation: Downward movement of water through the soil profile or other porous media.

Percolation rate: (1) The rate at which water moves through porous media, such as soil; and (2) intake rate used for designing wastewater absorption systems.

Perforated pipe (sprinkler): Pipe designed to discharge water through small, multiple, closely spaced orifices or nozzles, placed in a segment of its circumference for irrigation purposes.

Permanent wilting point: Soil water content below which plants cannot readily obtain water and permanently wilt. Sometimes called "permanent wilting percentage."

Permeable: Having pores or openings that permit liquids or gasses to pass through.

Permeability:

1. **Qualitative:** The ease with which gases, liquids, or plant roots penetrate or pass through a layer of soil or porous media.

2. **Quantitative:** The specific soil property designating the rate at which gases and liquids can flow through the soil or porous media.

Permeameter: Device for containing the soil sample and subjecting it to fluid flow in order to measure permeability or hydraulic conductivity.

Phreatophyte: Water plant.

Potential evapotranspiration: Rate at which water, if available, would be removed from soil and plant surfaces.

Pump-back system: A return flow system in which tailwater is pumped back to the head of an irrigation ditch for reuse.

Reservoir: Body of water, such as a natural or constructed lake, in which water is collected and stored for use.

Return flow: That portion of the water diverted from a stream which finds its way back to the stream channel, either as surface or underground flow.

Return-flow system: A system of pipelines or ditches to collect and convey surface or subsurface runoff from an irrigated field for reuse. Sometimes called a "reuse system."

Reuse system: See return-flow system.

Riparian: Of, on, or pertaining to the bank of a river, pond, or lake.

Root zone: That depth of soil which plant roots readily penetrate and in which the predominant root activity occurs.

Runoff: The portion of precipitation, snow melt, or irrigation that flows over the soil, eventually making its way to surface water supplies.

Saline: The condition of containing dissolved or soluble salts. Saline soils are those whose productivity is impaired by high soluble salt content. Saline water is that which would impair production if used to irrigate sensitive crops without adequate leaching to prevent soil salinization.

Second-foot: See cubic feet per second.

Sediment load: Amount of sediment carried by running water.

Sedimentation: Deposition of waterborne sediments due to a decrease in velocity and corresponding reduction in the size and amount of sediment which can be carried.

Seepage: The movement of water into and through the soil from unlined canals, ditches, and water storage facilities.

Seepage loss: Water loss by capillary action and slow percolation.

Siphon tube: Relatively short, light-weight, curved tube used to convey water over ditch banks to irrigate furrows or borders.

Slope: Degree of deviation of a surface from the horizontal, usually expressed in percent or degrees.

Soil classification: Systematic arrangement of soils into classes of one or more categories or levels to meet a specific objective. Broad groupings are made on the basis of general characteristics, and subdivisions are made on the basis of more detailed differences in specific properties.

Soil conservation: Protection of soil against physical loss by erosion and chemical deterioration by the application of management and land-use methods that safeguard the soil against all natural and human-induced factors.

Soil moisture: Water stored in soils.

Sprinkler irrigation: A method of irrigation in which the water is sprayed, or sprinkled, through the air to the ground surface.

Sprinkler systems:

1. **Boom type**: An elevated, cantilevered sprinkler(s) mounted on a central stand. The sprinkler boom rotates about a central pivot.

2. **Farm system**: System which will properly distribute the required amount of water to an entire farm.

3. **Field system**: That part of a farm system which covers one field or area for which it is designed.

4. **Hand move**: Method of moving the sprinkler system by uncoupling and picking up the pipes manually, requiring no special tools. This includes systems in which lateral pipes are loaded and unloaded manually from racks or trailers used to move the pipes from one lateral setting to another.

5. **Mechanized**: System which is moved either by engine power, tractor power, water power, or hand power on wheels or skids. Generally considered as any type of system that can be moved without carrying manually.

6. **Permanent**: System consisting of permanent underground piping with either permanent risers for sprinklers, or quick coupling valves, in such a manner that sprinklers may be attached.

7. **Self-propelled system**: Portable system which moves continuously when in operation. May rotate about a pivot in the center of field, or move laterally across the field in a predetermined direction.

8. **Semi-portable**: Systems designed with permanent pumping units and mains, but with portable sprinkler laterals.

9. **Side-roll system**: System, mounted on wheels, usually employing the lateral pipe line as an axle, where the lateral is moved at right angles to the mainline by rotating the pipeline either by hand or by engine power.

10. **Solid set**: System, either permanent or portable, which covers the complete field with pipes and sprinklers in such a manner that all the field can be irrigated without moving any of the system.

11. **Towed system**: System where lateral lines are mounted on wheels, casters,

sleds, or skids, and are pulled or towed in the field to be irrigated in a direction approximately parallel to the lateral.

Subirrigation: Applying irrigation water below the ground surface either by raising the water table within or near the root zone, or by use of a buried perforated or porous pipe system which discharge directly into the root zone.

Surface soil: Upper part of the soil ordinarily moved in tillage, or its equivalent in uncultivated soils, about 10 to 20 cm in thickness.

Surface water: An open body of water such as a river, stream, or lake.

Surge irrigation: A surface irrigation technique wherein flow is applied to furrows (or less commonly, borders) intermittently during a single irrigation set.

Tailwater: Applied irrigation water that runs off the lower end of a field. Tailwater is measured as the average depth of runoff water, expressed in inches or feet.

Tensiometer: Instrument, consisting of a porous cup filled with water and connected to a manometer or vacuum gauge, used for measuring the soil-water matric potential.

Varied amount - fixed frequency scheduling: Method of irrigation scheduling that involves water deliveries that vary in flow rate or amount over time, but that are made at constant intervals. An example is the rotation method when a minimum flow is delivered almost continuously. Considered a rigid term of scheduling.

Water budget: An analytical tool whereby the sum of the system inflows equals the sum of the system outflows.

Water conveyance efficiency: Ratio of the volume of irrigation water delivered by a distribution system to the water introduced into the system.

Water delivery system: Reservoirs, canals, ditches, pumps, and other facilities to move water.

Water demand: Water requirements for a particular purpose, as for irrigation, power, municipal supply, plant transpiration or storage.

Water holding capacity: Amount of soil water available to plants. See available soil water.

Water transfers: Selling or exchanging water or water rights among individuals or agencies.

Westwide: The 17 Western states in which Reclamation projects are located; namely, Arizona, California, Colorado, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Texas, Utah, Washington, and Wyoming.

Wetlands: Lands including swamps, marshes, bogs, and similar areas such as wet meadows, river overflows, mud flats, and natural ponds. An area characterized by periodic inundation or saturation, hydric soils, and vegetation adapted for life in saturated soil conditions.

Wetted perimeter: Length of the wetted contact between a conveyed liquid and the open channel or closed conduit conveying it, measured in a plane at right angles to the direction of flow.

Wilting point: The soil water content below which plants growing in that soil will remain wilted even when transpiration is nearly eliminated.

Appendix

RESOURCES

Documents

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